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Developments in PBD Technical Infrastructure: SFPE Engineering Design Guide and Engineering Practice Guides

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ABSTRACT

Performance based design will require improved technical infrastructure. This paper describes the ongoing efforts of the Society of Fire Protection Engineer to develop this technical infrastructure. SFPE Engineering Design Guide is a performance based engineering process document and Engineering Practice Guides provide documentation of analysis methods with established limitations and known accuracy. The first such guide assesses methods for predicting radiation from pool fires.

The process of identifying methods and data, and evaluating the methods for predicting radiation from pool fires was a straightforward but intensive process. The process worked well and the results provide a model for similar activities in the future. More refined methods for setting the safety factor based on a statistical approach need to be considered for the future.

The effort to date represents merely the very first steps in a process that needs to occur on an international scale. Some cooperative arrangements have been made, but more is needed. As there have not been any documents generated through the cooperative relationships up to this time, the effectiveness of the cooperation is a matter for speculation.

INTRODUCTION

The Society of Fire Protection Engineers has made a commitment to develop engineering practice documents. These documents are intended to evaluate analytical methods for use in fire protection engineering and to provide guidance in developing the input data required for the use of these analytical methods. In addition SPFE has developed the *SFPE Engineering Guide to Performance-Based Analysis and Design of Buildings,* which provides a framework for developing and assessing fire protection strategies to meet fire and life safety objectives.

ENGINEERING PRACTICE DOCUMENTS

The 1991 Conference on Fire Safety Design in the 21st Century[2] identified a number of strategies to realize the goal of developing a first generation performance-based building code which are directly related to developing the technical infrastructure required for performance-based design. These included making innovative engineering tools readily available in a usable, and establishing a mechanism for third-party validation of new (and old) engineering tools.

SFPE has created several task groups in support of the development of the technical infrastructure required for performance-based design; Computer Model Evaluation Task Group, Engineering Practices Task Group, and Performance-based Fire Safety Analysis and Design Task Group.

The Computer Model Evaluation Task Group has been developing an evaluation document for DETACT, the detector activation model developed by NIST based on technology which is now two decades old. The goal was to develop this first document on a simple but widely used computer model. While the TG has had some support from NIST, the efforts of the task group are that of volunteers. They have been working for several years and will soon release their first document. Given the simplicity of DETACT relative to other widely used models, this effort has shown that this will be a very long-term project.

The Engineering Practices Task Group's scope was to develop engineering practice guidance documents. The TG chose to work on the prediction of radiation from fires and its effect on targets because it is relatively simple. Subsequently, several task groups on other topics have been formed. The initial scope of the fire radiation document was limited to pool fire radiation, effects of radiation on humans, and ignition of combustibles by radiation. At this time the radiation from pool fires document has been published and the other two documents are complete and will be released in 2000. The goal of the documents is to review engineering methods available; including the data requirements and data sources, the assumptions of the method, the validation available for the method, and the limitations of the method. The engineering methods were compared with available data, and where possible, safety factors for use with the methods were developed. On a volunteer basis, this is an extraordinary effort. The magnitude of the work required to provide this treatment for all the engineering methods available is tremendous.

Academic institutions have had a significant role in the development of practice guides to date. This involvement has been through very small grants and through volunteer activities. Given the value to the educational missions of academia, the need for extensive work in evaluating engineering methods, and our profession's need for these documents, we need to find mechanisms to finance student research, which supports engineering practice guide development. While the development of engineering practice guides should include broad input from members of the engineering profession, the level of effort to complete evaluations of available engineering methods is beyond what can reasonably be expected to be completed through only volunteer efforts. Graduate students in Fire Protection Engineering are perfect candidates for this work. It supports the student's educational needs and graduate students are most capable of performing the work under appropriate direction.

Recognizing the need for engineering practice guides and the immensity of the task, the International Fire Safety Institute (IFSE) Working Group on Fire Engineering Guidance was convened in 1998. It was agreed that the member organizations (the Society of Fire Protection Engineers, the Australian Society of Fire Safety (SFS) and the UK Institute of Fire Safety (IFS)) would cooperative pursue development of engineering practice guides. The purpose of IFSEI is to support the globalization of the fire protection engineering profession and provide a forum to facilitate international collaboration. One of the activities being undertaken by IFSEI is international cooperation in developing engineering tools and data. This effort recognizing that codes and process would likely vary from country to country, but engineering tools and data would be universal. Therefore, IFSEI members agreed to collaborate on the development of fire safety engineering guidance by establishing a lead organization, with the remaining organizations acting as "peer reviewers" and identifying data from within their countries in the area.

Each of the three organizations would take primary responsibility for individual guides so that the large universe of guides that are needed will ultimately be authored via one of the three organizations. The first five projects undertaken by IFSEI were:

1. Room of origin fire hazards (SFPE lead),
2. Structural fire resistance (SFPE lead),
3. Occupant behavior and egress (IFS lead),
4. Risk, reliability, uncertainty (SFS lead), and
5. Fire brigade/department response (SFS lead).

Additional participation from other organizations is being sought. This international arrangement will go a long way to avoid duplication of efforts and can lead to documents with wide international acceptance. NFPA, ASCE, and many others, have roles to play in this process.

The Engineering Practice Guide and Computer Model Evaluation Task Groups are pursuing goals articulated in the 1991 Conference on Fire Safety Design in the 21st Century[2]. The question at this stage is whether they are making sufficient progress and are volunteer task groups actually capable of completing the needed work. The evidence at this time is that while credible documents are being developed, the pace of the ongoing work is too slow, and the scope of ongoing work is too narrow. The process needs to be supported financially to get the work done in a timely manner. The modest financial support to date has been vital and much more support can and would be effectively used to provide the documents, which are sorely needed.

The Performance-based Fire Safety Analysis and Design Task Group has made significant progress in developing a process document for performance-based design. The document is complete at this time and will be published by NFPA in 2000. This document provides a roadmap for the design team, the AHJ, and other interested parties. It defines the conceptual design process and provides guidance on documentation of the conceptual design. It draws upon the international experience (most clearly from the UK and Australia) in developing design process documentation for performance-based design. While this is a process document and contains no technical basis for design, it does define the process by which performance-based design is incorporated into the conceptual design process. International experience has indicated that such documents facilitate performance-based design by providing a clear definition of roles and process in the conceptual design process.

The Performance-based Fire Safety Analysis and Design Task Group differs from the Engineering Practice Guide and Computer Model Evaluation Task Groups. First and foremost, the document produced by the Performance-based Fire Safety Analysis and Design Task Group is a process document, and as such does not contain detailed engineering methods and rigorous evaluations of these methods. While the task of developing the process document was clearly challenging, the depth of the work is far less than in evaluations of engineering methods. Nonetheless, the development of the process document was funded by NFPA through a contract with SFPE at a level well above that available to the Engineering Practice Guide and Computer Model Evaluation Task Groups which received funding from NIST through a grant to SFPE.

The reality of the situation is that money makes the process work much faster. There is no doubt that without funding these documents can be produced, but they will take far too long without financial support.

It is equally clear that international collaboration is essential. There is no need for the documents to be national in nature, since performance requirements are not included in the documents. The documents simply describe and evaluate engineering methods and their technical applicability. Since the task of creating these documents is greater than any nation or organization can support or perform, the ongoing efforts to internationalize the process are important to making timely progress. So far, international cooperation has been good, but the scope of nations and organizations directly involved is limited.

AN ENGINEERING GUIDE: RADIATION FROM POOL FIRES

The goal of this engineering guide is to provide methods for predicting the radiation from a pool fire to a target outside the pool fire. This is a relatively simple problem, which has been studied over many decades. The strategy employed by the task group was to identify calculation methods available in the literature and assess each method with regard to the data requirements, data sources, model assumptions, model validation, and model limitations.

In order to perform these assessments, the task group also identified all relevant heat flux measurements performed for targets outside of pool fires. The scope of the models and assessment was limited to pools greater than one meter in diameter. Fourteen experimental investigations were identified. These included 32 experiments with a total of over 100 data points. Pool diameters ranged from one meter to 50 meters, and the fuels included kerosene, gasoline, heptane, crude oil, JP fuels, LNG, methanol, and toluene.

Four calculation methods were identified in the literature. The simpler methods included a power law correlation and the point source model. Two methods based on cylindrical radiators were identified and evaluated.

The evaluation of the methods is organized as follows:

1. Method description,
2. Data requirements for the method,
3. Data sources available,
4. Method assumptions,
5. Method validation,
6. Method limitations, and
7. Recommended factor of safety for the method.

The goal of the first four sections is to provide a clear description of the method, its assumptions, and what data is needed for the calculation. For the cylindrical radiator models graphical methods for assessing the configuration factor are included for the convenience of the user. The core of the evaluation is the method validation section. Here the available database is used to evaluate the performance of the method. The primary method of evaluation used in this guide is plots of predicted vs. measured heat flux. Different types of data are identified by the symbol used to allow an overall assessment of the method as well as information as the scenarios that the method has the greatest difficulty predicting. The limitations section uses the information provided by the method developer as well as the validation results to identify when and where the method can be credibly applied. The safety factor section provides an indication of the factor of safety required in the method t achieve conservative predictions, based primarily on the method validation section. Finally there is a summary section which provides general recommendations regarding the selection and use of methods.

The results of the evaluation were somewhat surprising. The preferred method for heat fluxes below 5 kW/m^2 was the simple point source model. This would include applications where equipment damage or effects on humans are the hazards of concern. The simple point source method performed better than the more complex cylindrical radiator methods. The comparison is somewhat unfair, however, since the point source model had no associated method for determining the radiative fraction. A correlation of the radiative fraction as a function of pool diameter was developed using the validation data set. As such, a parameter in the model was assessed through a correlation based on the validation data set.

For heat fluxes greater than 5 kW/m^2, the preferred method was that of Shokri and Beyler cylinder method. There is no doubt that the method could be further optimized, but the goal of the task group was to evaluate existing methods, not to modify or create new ones.

All the methods evaluated required a factor of safety of two in order to conservatively predict heat fluxes. However, the preferred methods provided better correlation of the data and as such did not overpredict as greatly as the other methods evaluated.

CONCLUSIONS

The process of identifying methods and data, and evaluating the methods for predicting radiation from pool fires was a straightforward but intensive process. The process worked well and the results provide a model for similar activities in the future. More refined methods for setting the safety factor based on a statistical approach need to be considered for the future.

The effort to date represents merely the very first steps in a process that needs to occur on an international scale. Some cooperative arrangements have been made, but more is needed. As there have not been any documents generated through the cooperative relationships up to this time, the effectiveness of the cooperation is a matter for speculation.

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